S.S. PAPADOPULOS & ASSOCIATES, INC.
Environmental & Water-Resource Consultants

Memorandum

Date: September 19, 2019

From: Erica DiFilippo, Matt Tonkin, Christopher Neville, Xiaomin Wang (SSP&A)

To: Judy Canova and David Wilson (USEPA Region V)

Project: SSP-1453, Task 39

Subject: **Comments on 2004 Groundwater Modeling Report Prepared by Conestoga-Rovers & Associates (CRA)**

S.S. Papadopulos & Associates, Inc. (SSP&A) has reviewed the groundwater modeling report entitled *"Hydrogeologic Modeling Report, Pristine, Inc. Site, Reading Ohio"* (herein referred to as the Report) prepared in February 2004 by Conestoga-Rovers & Associates (CRA) for the Pristine, Inc. Superfund Site (herein referred to as the Site). The Report describes a three-dimensional groundwater flow and transport model which was developed for the Site based on:

- Hydrogeologic properties based on regional data from the Mill Creek Valley, including reported regional hydraulic conductivity values and single-well response tests (SWRTs) from off-Site wells;
- Hydrogeologic properties based on Site-specific conditions, including pumping tests, SWRTs, boring logs and grain size analysis;
- Pumping rates from the on-Site pump-and-treat system, and;
- Pumping rates from the City of Wyoming municipal well field.

The groundwater flow model was calibrated under both steady state and transient conditions. The calibrated model was then used to simulate the transport of 1,2-Dichloroethane (1,2-DCA) using the solute fate-and-transport simulator MT3DMS.

Groundwater modeling at the Site has been an iterative process. At this time, 15 years have elapsed since the release of the Report in 2004 by CRA. The 2004 CRA model described in the Report was based, in part, on a groundwater flow model that was created for the GE Aviation Site, located due west of the Site (O'Brien and Gere, 2001). The GE Aviation Site model was itself later refined in 2011 at which time it incorporated aspects of the 2004 CRA groundwater flow model, foremost the geology (O'Brien and Gere, 2011). The 2011 GE Aviation Site model was later used by SSP&A in a 2018 evaluation of monitored natural attenuation (SSP&A, 2018). Recently, SSP&A modified the 2011 GE Aviation Site model to account for discrepancies between geologic cross sections presented in the Report and the discretization of the 2011 GE Aviation Site model layers and hydraulic conductivity zonation. As part of that effort, the steady-state 2011 GE Aviation model was converted into a transient model to evaluate the correspondence with and impacts of changes in the groundwater pump-and-treat (P&T) system at the Site.

Below, SSP&A presents comments on the groundwater flow and transport model that is presented in the 2004 Report. The comments are grouped into two categories: (1) General Comments, and; (2) Specific Comments. It is recognized that the various updates to the model since it was detailed in the 2004 Report may have partially or wholly addressed some of these comments. The 2004 groundwater flow and transport model, along with the more recent updates by O'Brien and Gere and SSP&A, is a useful tool with which to evaluate the fate and transport of organic contaminants at the Site.

General Comments

1. The groundwater flow model was developed specifically to represent the Lower Aquifer (LA) and does not attempt to simulate groundwater flow and transport in the overlying, unconfined aquifer or the intervening fine-grained semi-confining units. This limits the use of the groundwater flow and transport model for simulating leakage of groundwater and contaminants from the upper aquifer in the on-Site area[1].
2. It is unclear what criterion was used to determine the zone of influence of municipal well fields which was used, in part, to determine the locations of the model boundaries.
3. The presentation and discussion of recharge is confusing. Because the model simulates only the LA, recharge as it is used in the groundwater flow model actually represents leakage from the overlying aquifer via intervening fine-grained units and not direct infiltration of precipitation[2].
4. The benefit of using two measurement events to develop the steady-state groundwater flow model is unclear. In the Report, it states that the two events (November 27, 2000 and April 9, 2003) reasonably reflect steady-state conditions. As seen in the hydrographs of MW68, MW69 and MW70, groundwater elevations are not steady at the November 27, 2000 event. Given this, one steady-state calibration model representing long-term average conditions would be preferable[3].
5. With regard General Comment #4, further analysis would be required to understand the differences in water levels observed between the two dates selected for steady-state groundwater flow calibration. The steady-state calibration models developed to match observations on November 27, 2000 and on April 9, 2003 differ in (a) specified constant-head boundaries and (b) pumping rates. The constant hydraulic head boundary

[1] The revised 2011 GE Aviation Site groundwater model incorporates the shallow, unconfined aquifer, which will allow for assessment of leakage of contamination from on the on-Site area to the Lower Aquifer and the off-Site area.
[2] Because the 2011 GE Aviation Site groundwater model includes the shallow, unconfined aquifer, recharge from precipitation is handled appropriately.
[3] The SSP&A modified model is a steady-state model with the yearly average conditions using for prediction and was converted into a transient model to evaluate the correspondence with and impacts of changes in the groundwater pump-and-treat (P&T) system at the Site.

conditions were increased uniformly by 2.25 ft in the April 9, 2003 calibration to reflect the fact that groundwater elevations measured on April 9, 2003 are about 2 ft higher on average than those measured on November 27, 2000. It is indicated in the report that the groundwater elevation increase may be caused by decreased pumping (15 percent decrease in pumping from the City of Wyoming well field and/or 9 percent decrease in LA Extraction System pumping). Higher groundwater elevations on April 9, 2003 were observed in MW68, MW69 and MW70 hydrographs; however, there is no evidence that the assumption holds across the entire Site due to the distribution of the monitoring network mainly in the proximity of the Pristine Site. If there are insufficient data to reflect the systematic increase of the groundwater elevations throughout the Site, the only change for the April 9, 2003 model should be the pumping rates.

6. Despite the foregoing, separate analyses could be considered for the spring and winter seasons. Seasonal fluctuations in water levels between winter and spring months during 1998 and 2003 at monitoring wells MW71 to MW76, MW92 to MW93, MW96 to MW99, MW102, MW104 and MW105 are shown on Table 2.4. In 1998 and 1999, the groundwater elevations in the winter are greater than the levels observed in the spring. The average differences are 0.18 ft and 0.16 ft, respectively. In contrast, greater fluctuations in groundwater levels in the spring have been observed since 2000, with differences between spring and winter ranging from 0.23 ft to 1.26 ft. Two (or more) factors may contribute to the fluctuations between spring and winter in 1998 and 1999: the cessation of pumping from the City of Reading municipal wells since 1994 and the startup of pumping from the LA Extraction System since November 1997.
7. The LA Extraction System started operating in October 1997 with EW1, EW2 and EW3 pumping. EW4 and EW5 started pumping in October 1998. The groundwater elevation declined prior to 2001 might due to the startup of pumping. The groundwater elevation increased significantly in 2002, particularly at MW70. The increase may be attributed to decreased pumping at EW3, EW4 and EW5 in March 2002 and may also be related to seasonal groundwater elevation fluctuations. However, MW68 to MW70 are located over 1000 ft from EW3, EW4 and EW5. The rise of the groundwater elevation due to reduced pumping of the three pumping wells is less likely.
8. The transient groundwater flow model shows some systematic deficiencies in the calibration, examples of which are detailed in the Specific Comments presented below.
9. It is difficult to assess the quality of the fate-and-transport model calibration and predictions based on the materials presented in the Report because there is a lack of documentation of the source history. Characterization of the source and source history play a very important role in the analysis of long-term fate and transport process, and the use of contaminant transport models to make reliable predictions of future fate.

Specific Comments

1. No regional-scale data were incorporated to constrain the elevation of the top of the LA. The elevations of the top of LA throughout the Site were interpreted using kriging and are shown in Figure 5.5 (reproduced below). Bulls-eye shapes in the contours can be observed which may be largely due to the distribution of data and strong contrasts in the elevations at neighboring locations. The data are sparse in the southern part of the model domain, particularly along the eastern and western sides of Mill Creek Valley. In contrast to other model surfaces (bedrock), no previous interpretations were incorporated to constrain the elevation of the top of the LA.

figure 5.5
TOP OF LA ELEVATION CONTOURS
PRISTINE, INC. SITE
Reading, Ohio

2. Mill Creek and the West Fork Creek are not represented in the 2004 model because they are assumed to impact the unconfined aquifer above the LA and not the LA directly (see General Comment #1). Mill Creek and the West Fork Creek should be simulated explicitly in the model, using the MODFLOW River or Drain packages for example, when the model is expanded to include the upper unconfined aquifer in the area of the Site. The potentiometric surface contours of November 2000 shown in Figure 3.1 by Schalk and

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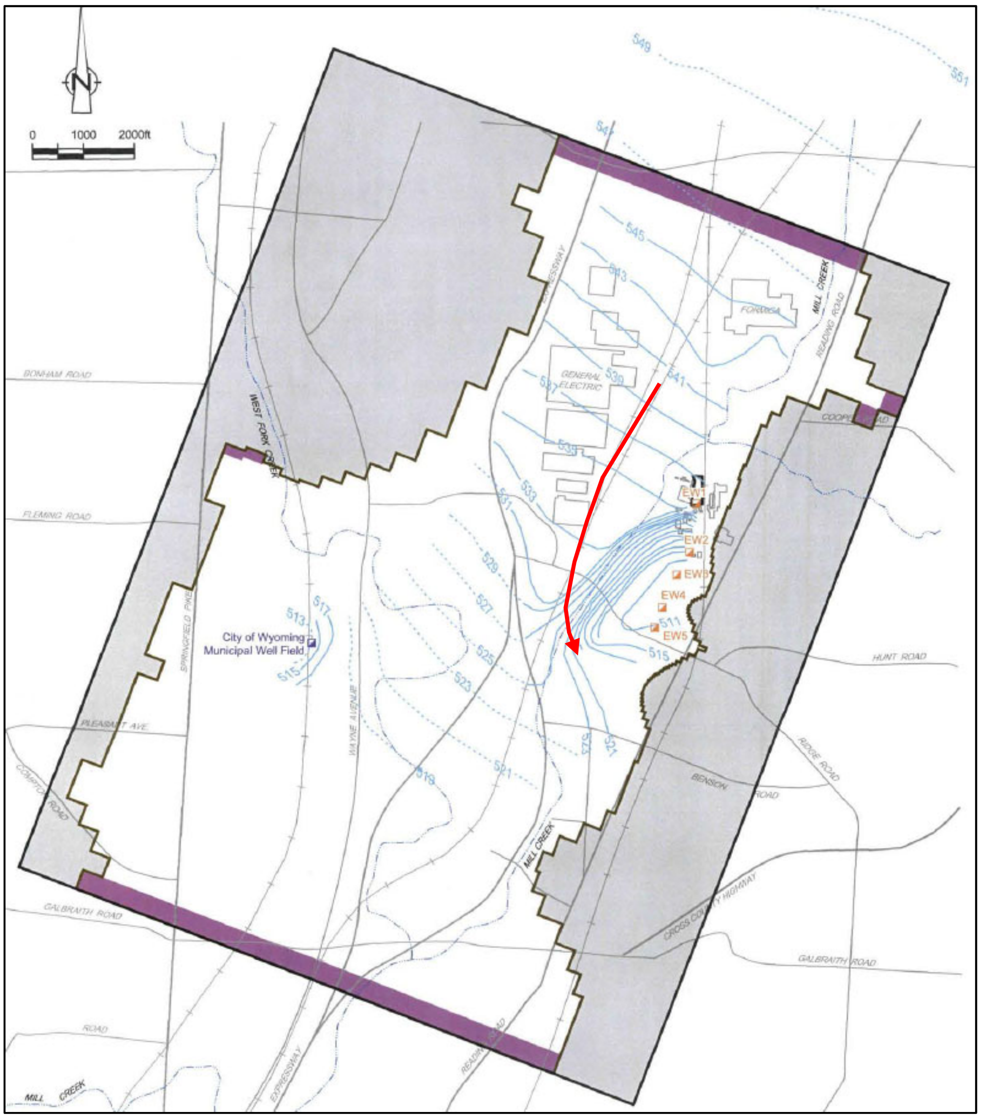
Schumann (2002)[4] show evidence of water discharging to the Mill Creek following the red line in the figure below[5].



4 Schalk and Schumann, 2002. Hydrogeology, Ground-Water Use, and Ground-Water Levels in the Mill Creek Valley Near Evendale, Ohio. United States Geological Survey in cooperation with the U.S. Air Force Aeronautical Systems Center. Water-Resources Investigations Report 02-4167.

5 The 2011 GE Aviation Site model does properly represent Mill Creek and the West Form Creek.

3. Comments on hydraulic conductivity and transmissivity values used in the model:
    a. The groundwater flow model does not incorporate some of the finer-scale heterogeneity in geology, and hence hydraulic conductivity, that is shown in the cross-sections A-A` through F-F`[6].
    b. Single well response tests (SWRTs) may have a localized influence and inference, whereas constant rate pumping tests (like those performed in extraction wells EW-1 and EW-4) are likely to have a larger influence and inference and should dominate the estimation of aquifer properties for the model.
    c. It is unclear, and not discussed, whether the high drawdowns observed in extraction well EW-4 is due to well efficiency (losses) or aquifer properties.
    d. The model selected hydraulic conductivity values might not be representative throughout the entire model domain. Hydraulic conductivities for LA were estimated with two approaches: single-well response tests (SWRTs) and a constant-rate pumping test at EW1. The interpreted hydraulic conductivity estimates are focused in the vicinity of the Pristine Site. As shown in Figure 2.1 of the Report, the model area extends well beyond the limits of the Pristine Site. The hydraulic conductivity values reported by others are restricted to isolated areas of the Mill Creek Valley.
    e. The simulated water level contours from the steady-state simulation for November 27, 2000 are generally 1 ft lower than the interpreted LA potentiometric surface contours for that date [USGS WRIR 02-4167, Schalk and Schumann (2002)]. In addition, the cones of depression for the pumping wells EW3, EW4 and EW5 are very different from the interpreted water levels (Figure 6.1b: black contours denote interpreted groundwater levels, blue contours denote simulated groundwater levels). The 2004 model over-predicts the groundwater elevations around the well field in areas represented by hydraulic conductivity zones 5 & 7. In addition, the simulated hydraulic gradient is smaller than the observed by a factor of 2 to 3. These factors suggest that the hydraulic conductivity values assigned in zones 5 and 7 might be too large. A similar pattern can be observed in the water levels for the April 9, 2003 steady-state simulation (Figure 6.2b): simulated hydraulic gradients again appear smaller than the observed by a factor of about 2 to 3.

[6] Modifications by SSP&A of the 2011 GE Aviation Site model attempt to rectify the geologic cross-sections and the hydraulic conductivity zones in the model.

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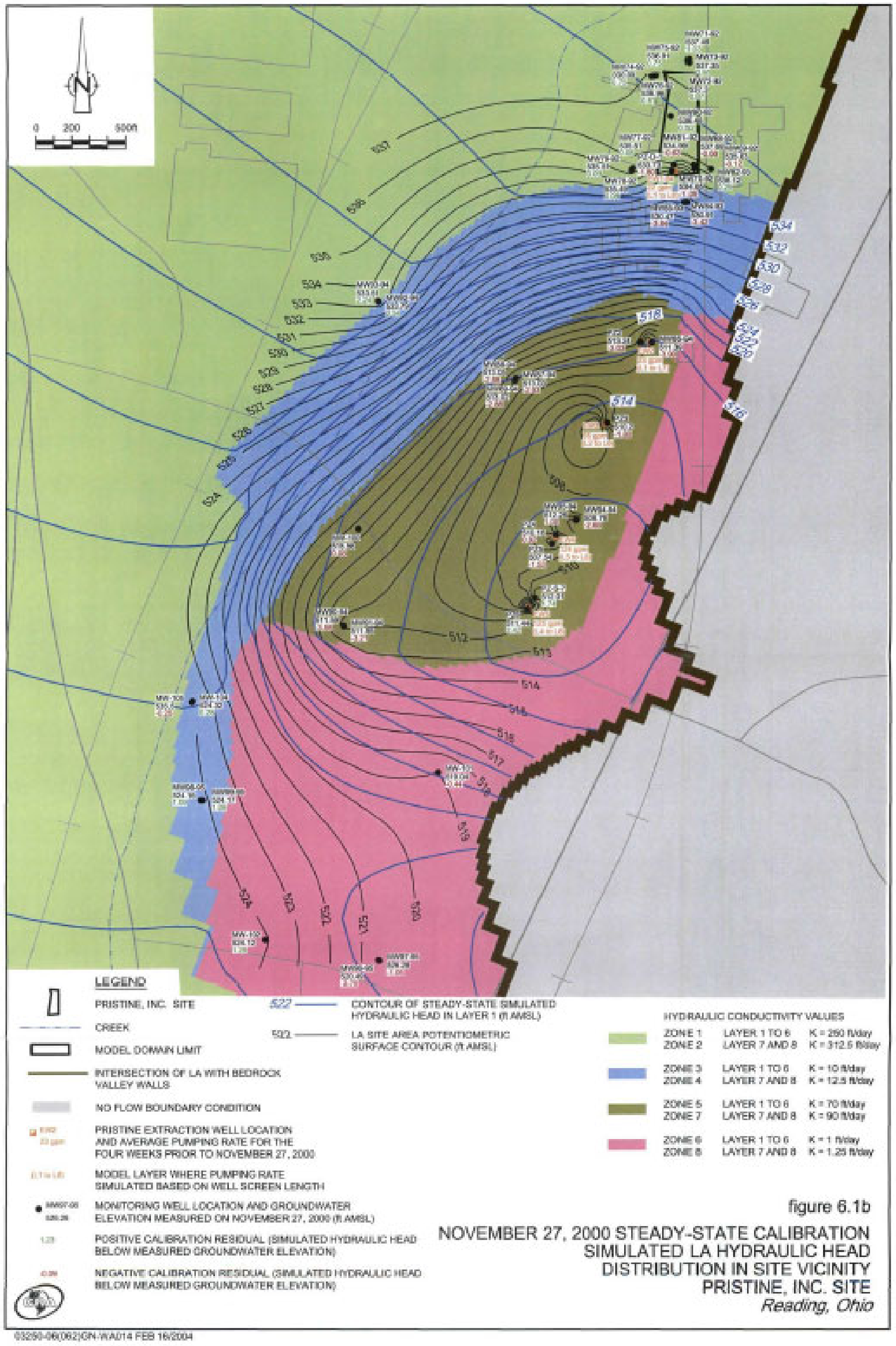

figure 6.1b

NOVEMBER 27, 2000 STEADY-STATE CALIBRATION SIMULATED LA HYDRAULIC HEAD DISTRIBUTION IN SITE VICINITY PRISTINE, INC. SITE *Reading, Ohio*

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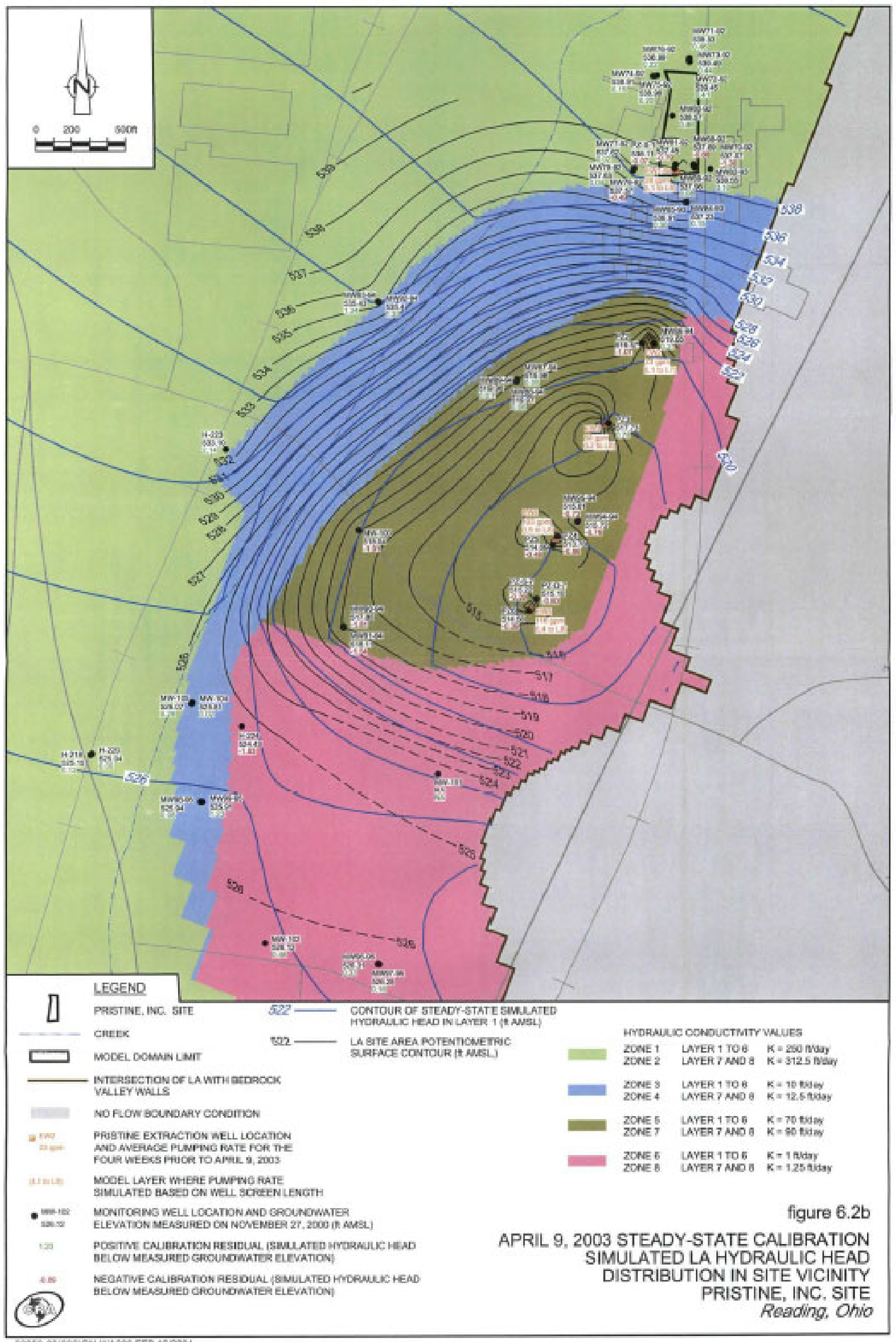
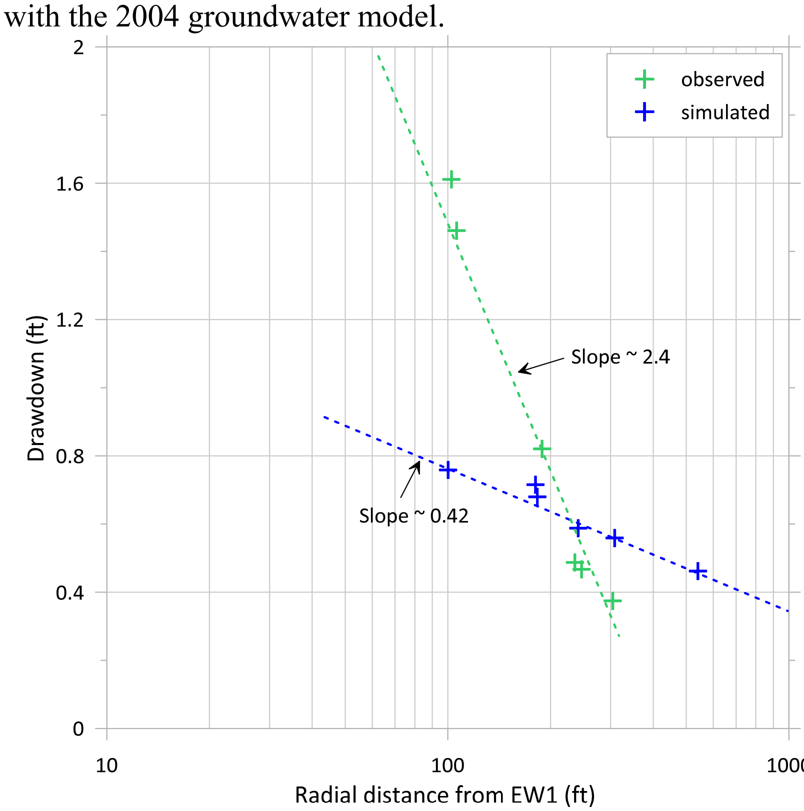


f. The transmissivity specified in the numerical model is about 6 times higher than can be inferred from the drawdowns observed during the EW1 pumping test. The transient calibrated model for the EW1 72-hour pumping test shows reasonable agreement between simulated and observed drawdowns distant from the pumping well (Figure 6.5). The model under-predicts the drawdowns close to EW1 by approximately 0.8 ft. The distance-drawdown plot for the EW1 pumping test has been digitized and reproduced with semi-log axis (see figure below). The observations and the simulation results approximate two very different straight lines. The ratio of the slopes of the two lines is about 5.7, which suggests from Cooper-Jacob analyses that the transmissivity specified in the numerical model is about 6 times higher than is inferred from the observations. It is possible to obtain relatively good matches for the steady-state calibrations but have the transmissivity wrong by a factor of 6 by specifying constant-head boundaries in the model, as was done with the 2004 groundwater model.



g. At MW94, close to pumping well EW4 (within hydraulic conductivity zones 5 & 7), the transport model over-predicts concentrations, implying that the plume has not been captured by the pumping well as soon as expected. This may be another line of evidence that the transmissivity around the well fields is too large.

4. Comments regarding calibration and sensitivity analysis for the groundwater flow model:
    a. As seen in the Figure 6.3 and Table 6.2 of the Report for the November 27, 2000 simulation, although most of the targets fall on the line of equality, about 40 percent of targets (16 out of 44 targets) with the absolute residuals larger than 2 ft. The residual statistics shows that the absolute mean residual is 1.51 ft and the maximum and minimum residuals are 2.54 ft and -3.99 ft. Overall, the residual of 2 ft may be acceptable, as the groundwater elevation at MW70 between 2000 and 2001 vary by about ±1.75 ft. This April 9, 2003 steady-state model shows a better result with the absolute mean residual of 0.67 ft. The simulated water levels are generally within 2 ft of the observed water levels with only one exception (H223).
    b. Figure 6.7 shows the results of the sensitivity analyses for the April 9, 2003 steady-state model. The model input parameters have been grouped and simulations were conducted with a variety of values from each group. The report stated that "*an improved model calibration could not be obtained by the applied variations to the calibrated model input parameters*". However, trial no. 2, the uniform hydraulic conductivity variation group is clearly a winner, the result of which is shown in Figure 6.7. The parameters in trial no. 2 are not the ones used in the calibrated model. It is not indicated why this group of sensitivity analyses was neglected.
5. Comments regarding the fate-and-transport model:
    a. The simulated concentrations histories using the original transport model show relatively poor matches to observed concentrations (see Figures C.1.2 – C.1.22). While calibration of transport models is a difficult task, when a model is used to support a remedy that incorporates a monitored natural attenuation (MNA) component, the importance of transport model calibration is increased.
    b. The mismatch of transport simulation results to observations is particularly evident at locations outside the plume center such as MW84, MW87 and MW94. Sensitivity analyses were conducted on two parameters, longitudinal dispersivity and sorption coefficient. The results show that reducing the longitudinal dispersivity, α_L, to half (i.e., 21ft) improves the match considerably at wells where the initial match is relatively poor. Comparisons of the match between the initial transport simulation and the sensitivity analysis #1 at three monitoring locations, MW84, MW87 and MW94 are shown below. The trends are similar, but the simulated magnitudes of the concentrations are closer to those observed.

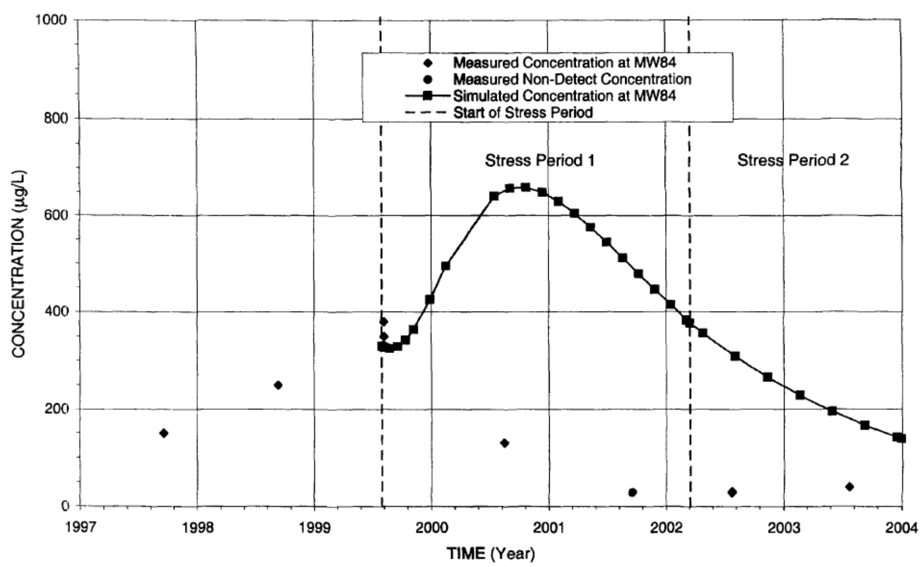


figure C.1.1
SIMULATED VS OBSERVED 1,2-DCA CONCENTRATION PROFILE - MW84
PRISTINE, INC. SITE
Reading, Ohio

Original model,
α_L = 42 ft

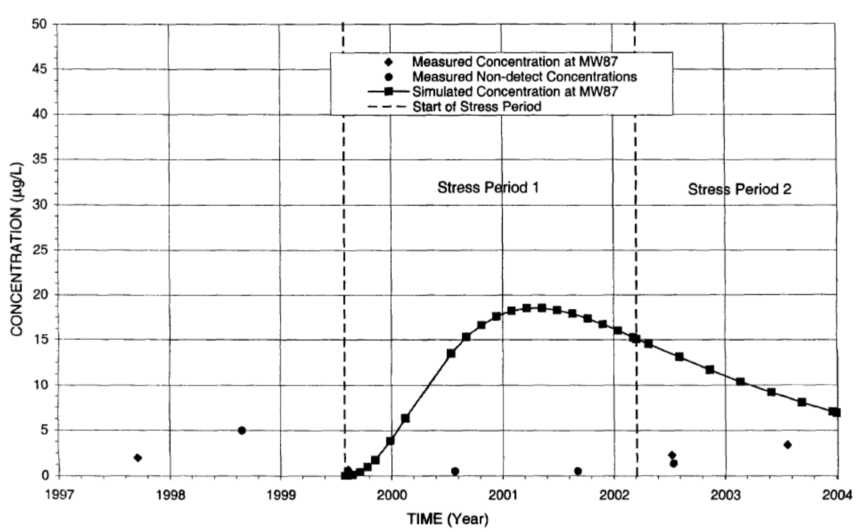


figure C.1.4
SIMULATED VS OBSERVED 1,2-DCA CONCENTRATION PROFILE - MW87
PRISTINE, INC. SITE
Reading, Ohio

Original model,
α_L = 42 ft

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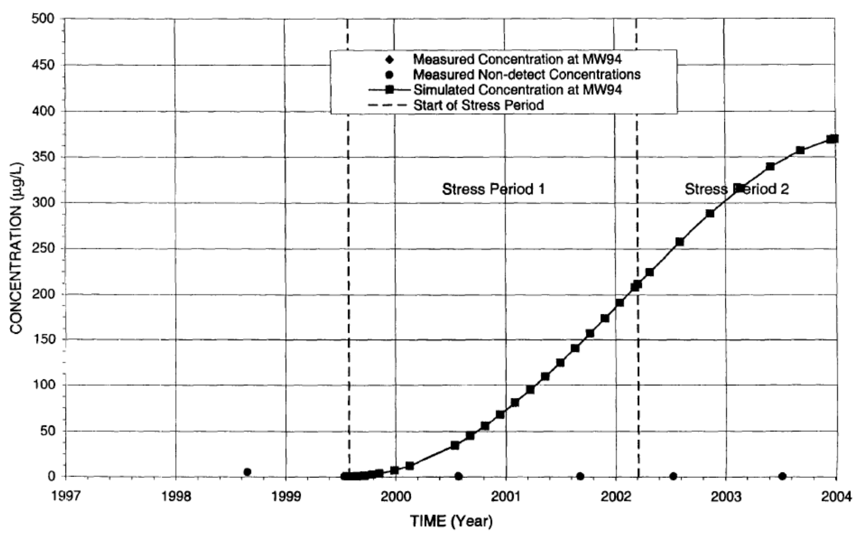


figure C.1.11
SIMULATED VS OBSERVED 1,2-DCA CONCENTRATION PROFILE - MW94
PRISTINE, INC. SITE
Reading, Ohio

Original model,
$\alpha_L = 42$ ft

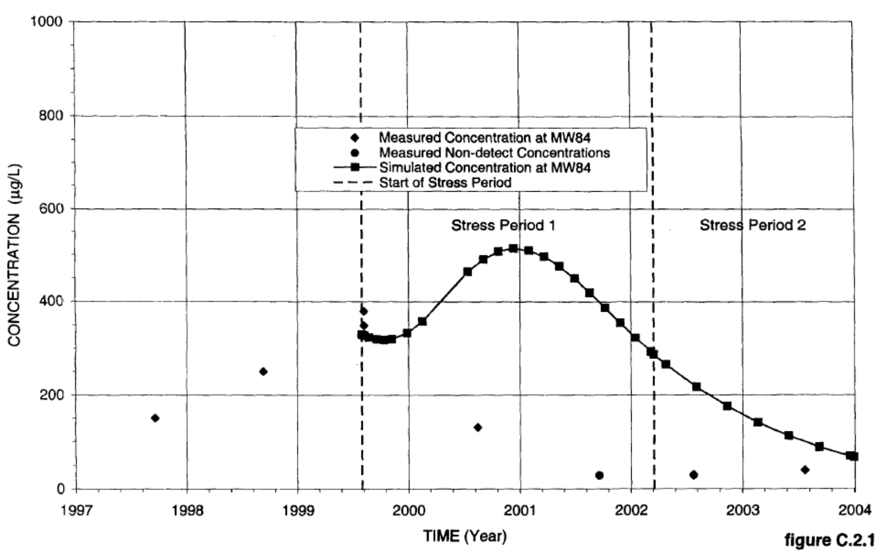


figure C.2.1
TRANSPORT SENSITIVITY SIMULATION 1
DISPERSITY DIVIDED BY 2
SIMULATED VS OBSERVED 1,2-DCA CONCENTRATION PROFILE - MW84
PRISTINE, INC. SITE
Reading, Ohio

Sensitivity analysis #1,
$\alpha_L = 21$ ft

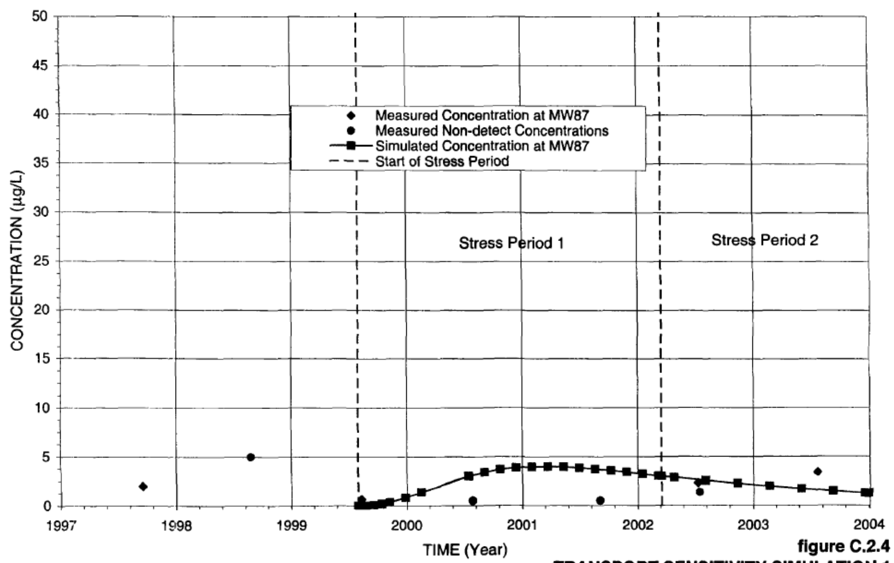


figure C.2.4
TRANSPORT SENSITIVITY SIMULATION 1
DISPERSITY DIVIDED BY 2
SIMULATED VS OBSERVED 1,2-DCA CONCENTRATION PROFILE - MW87
PRISTINE, INC. SITE
Reading, Ohio

Sensitivity analysis #1, $\alpha_L = 21$ ft

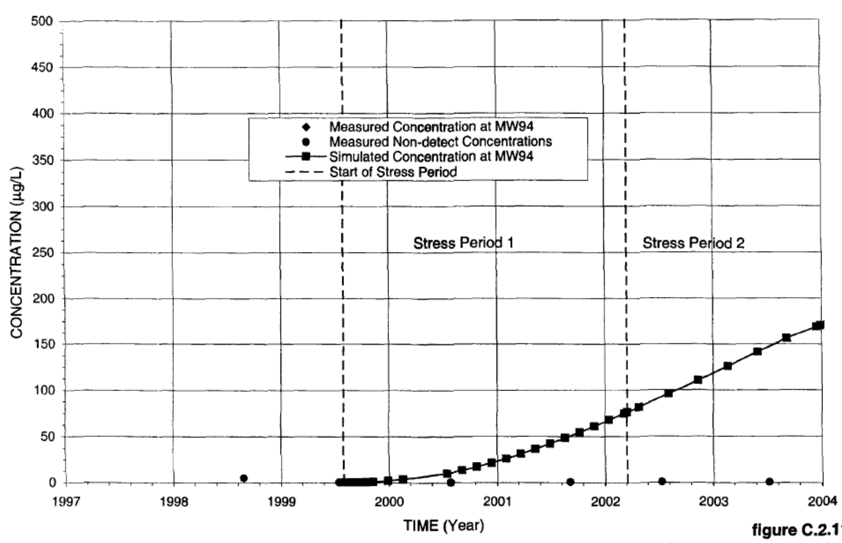
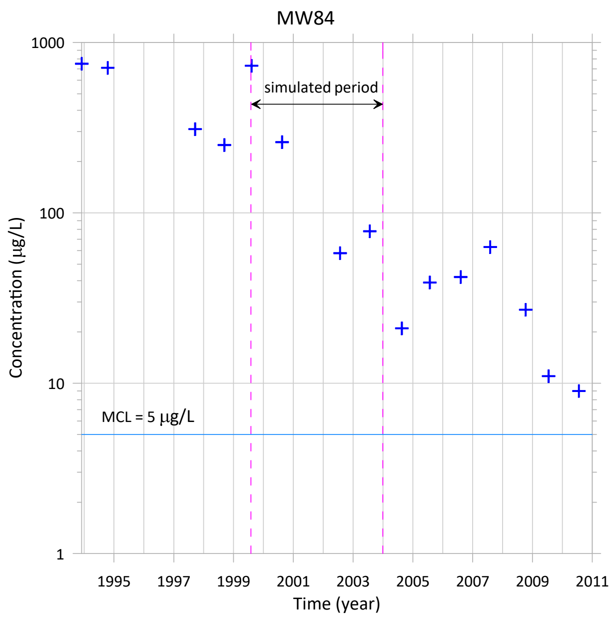
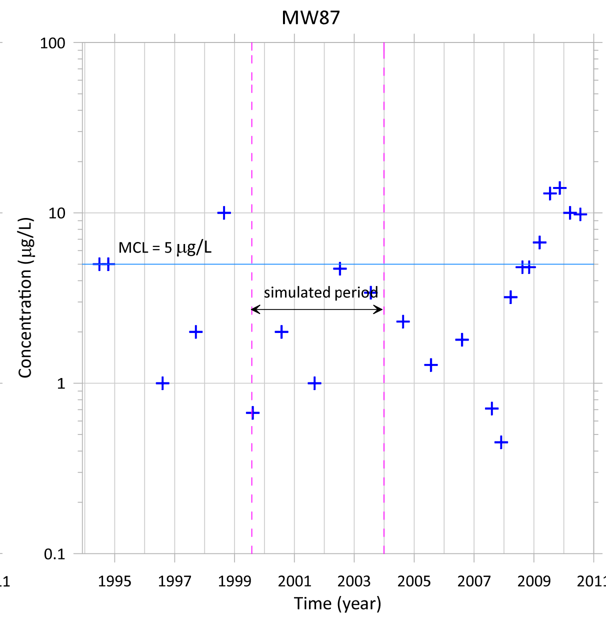


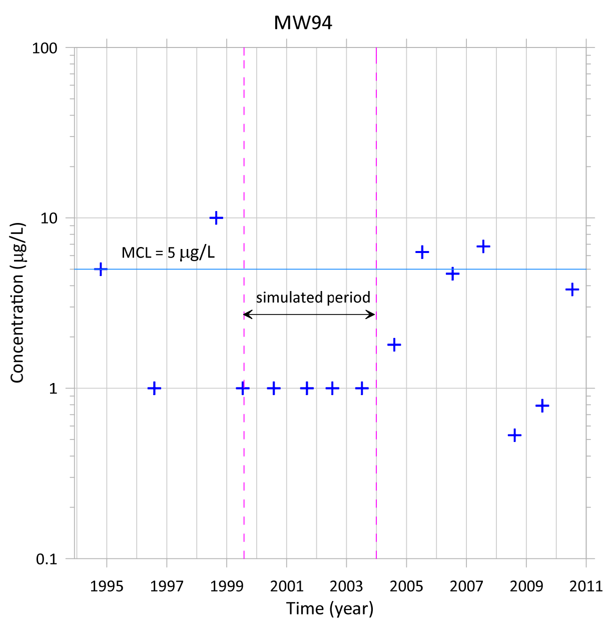
figure C.2.11
TRANSPORT SENSITIVITY SIMULATION 1
DISPERSITY DIVIDED BY 2
SIMULATED VS OBSERVED 1,2-DCA CONCENTRATION PROFILE - MW94
PRISTINE, INC. SITE
Reading, Ohio

Sensitivity analysis #1, $\alpha_L = 21$ ft

c. The monitoring program has continued since the completion of the modeling in 2004. The 1,2-DCA concentrations history have been retrieved from the *Round 36 Monitoring data*. The complete concentration histories at the three monitoring wells MW84, MW87 and MW94 are presented below. The figure shows that concentrations in MW84 and 94 have remained low and show no signs of rising, whereas concentrations in MW87 show significant increases since 2008. This could be caused by cessation of pumping at EW2 in 2006 and at EW4 in 2007. In future work, the evolution of the plume should be investigated in greater detail. In particular, the model should be updated to reflect the important time-series histories observed at MW84 and other observation wells.


MW84
1000
100
10
1
simulated period
MCL = 5 µg/L
Concentration (µg/L)
1995
1997
1999
2001
2003
2005
2007
2009
2011
Time (year)


MW87
100
10
1
0.1
MCL = 5 µg/L
simulated period
Concentration (µg/L)
1995
1997
1999
2001
2003
2005
2007
2009
2011
Time (year)


MW94
100
10
1
0.1
MCL = 5 µg/L
simulated period
Concentration (µg/L)
1995
1997
1999
2001
2003
2005
2007
2009
2011
Time (year)